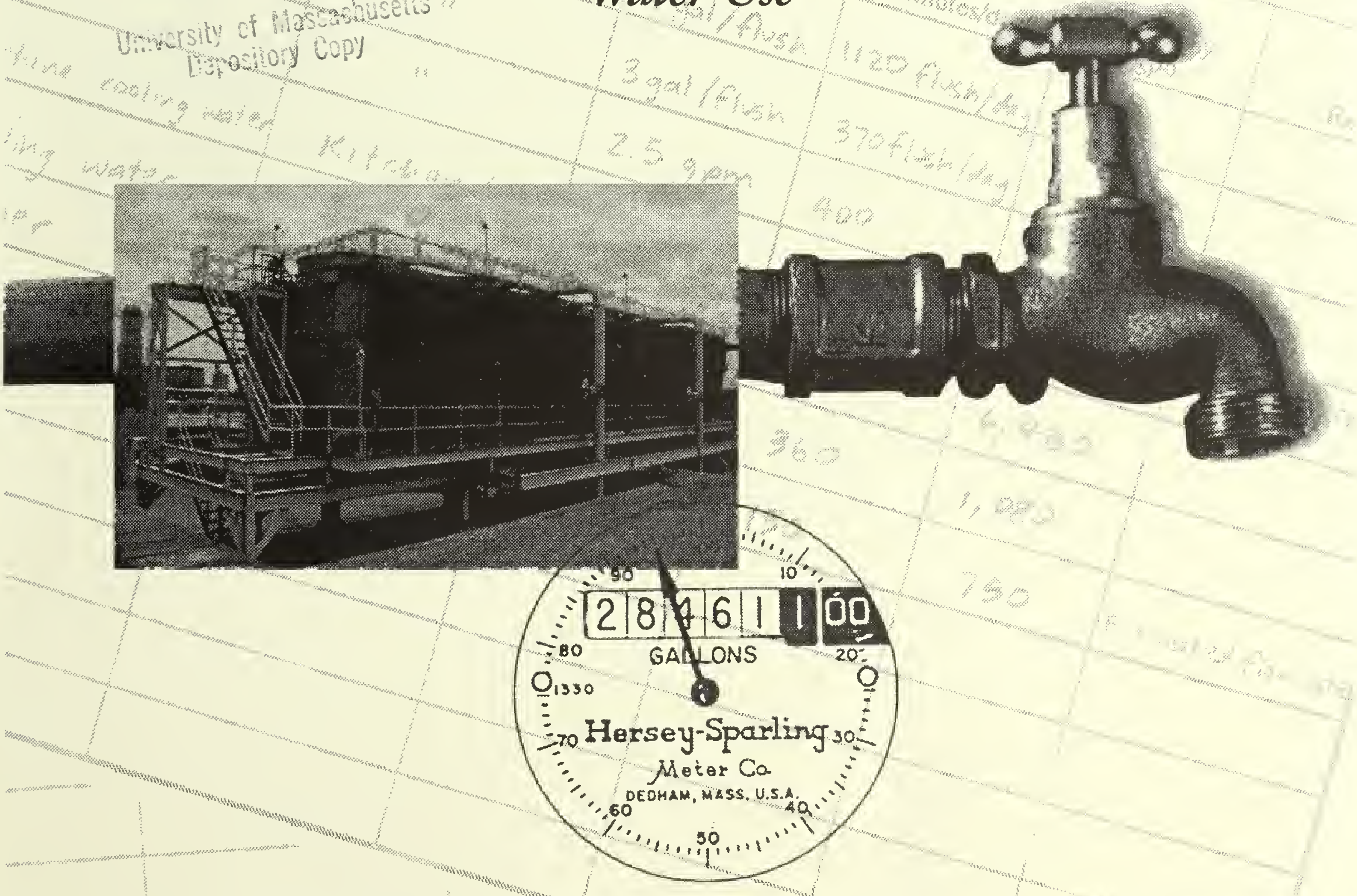
MASSACHUSETTS WATER RESOURCES AUTHORITY

A Guide to Water Management

The MWRA Program for Industrial, Commercial and Institutional Water Use



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A GUIDE TO WATER MANAGEMENT

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Prepared under the direction of
Douglas B. MacDonald, Executive Director

THE INDUSTRIAL, COMMERCIAL AND INSTITUTIONAL (ICI) WATER MANAGEMENT PROGRAM
Marsha Gorden, Project Manager
Dan Thompson, Project Engineer
John DiPietro, Engineering Intern
Kevin Sullivan, Engineering Intern

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Executive Summary

As a corporate official or plant manager, you have an opportunity to use water efficiently. This guidebook contains information which will help your company save money, meet regulations, and use water in a productive manner.

The guidebook works in two ways. It has an easy to use format which can organize a corporate water management plan or it can help locate specific answers to your water use questions.

You will find all the steps to organizing your own in-company plan for efficient water use. Details are given for:

- taking an inventory of how you use water
- determining how much the water costs and
- implementing the efficiency measures.

Or you can look up specific water use categories relevant to your company. Do you think your cooling tower is inefficient or that your kitchen is wasting water? There are sections on these uses as well as on sanitary and cleanup. Each section includes alternatives and costs and typical paybacks.

All that's missing is someone to start the process. Take the challenge to make your company water efficient:

- appoint someone to take responsibility
- give them access to information on water bills and
- respond to the financial alternatives which are appropriate for your company.

You'll find this guidebook helpful as you look for solutions with the shortest paybacks. We thank you for helping the Massachusetts Water Resources Authority conserve its most precious resource.

Contents

Introduction

This guidebook has been developed by the Massachusetts Water Resources Authority to help businesses, industries, and institutional facilities improve the water efficiency of their operations. Improved water efficiency may provide several benefits:

- Reduced operating costs.

- Compliance with certain regulations (such as those requiring water-efficient plumbing).

- Enhanced image in the community as an environmentally-responsible establishment.

- Preservation of our water resources and reduced probability of future shortages.

The measures described in this Guide can result in cost savings for your facility, help preserve our water supply, and help meet environmental protection requirements and goals.

Properly selected efficiency measures not only reduce your water demand, they also rapidly pay for themselves and deliver lasting savings. In today's economy, facilities of all types are seeking ways to reduce their overhead and operating costs.

This Guide tells you how to analyze your own facility step by step to identify opportunities for improved water management. It is intended as a hands-on document that you can use regularly. The workbook format allows you to add worksheets and other materials to help you identify and implement savings in your own facility.

Specific suggestions are provided of proven water efficiency measures that have worked successfully elsewhere. Some actions have little or no cost, while others do require a capital investment. Some water efficiency measures involve reducing the flow used by existing equipment, while others consist of reuse of good quality water (e.g., steam condensate) for other purposes. From the payback information included, you may be surprised at how quickly an investment in water management is repaid by savings in water, wastewater, and related costs.

This booklet contains two principal sections: recommended guidelines to assist you in developing an in-house water management plan for your facility, and descriptions of potential water efficiency measures (WEMs). The water management plan is a step by step procedure that facility staff can fol-

low to identify practical, realistic opportunities to reduce cost and save water through improved water efficiency. The water efficiency measures are specific actions that have proved to be cost effective for other facilities. WEMs are suggested for consideration in the following categories:

- Domestic/sanitary uses.
- Water for cooling purposes.
- Boilers and steam systems.
- Kitchens.
- Laundries.
- General washing and clean-up.

At the conclusion of this document is a section on maintenance, as well as additional information and resources, including do-it-yourself worksheets to assist in carrying out your water management plan.

MWRA's Industrial, Commercial and Institutional (ICI) Water Management Program

Since 1988, the MWRA's Industrial, Commercial, and Institutional (ICI) program has been helping facilities identify practical, cost-effective water management and conservation techniques.

In its first six years of operation, the ICI program conducted more than 80 audits and over 100 workshops to introduce new water conservation opportunities to the region's companies and institutions. Many water-conserving measures have resulted in capital cost payback periods of less than two years.

Specific services available to you from MWRA's ICI water management program are:

- Descriptions of water conservation techniques for specific types of facilities.
- Scheduled workshops in your community to discuss problems and potential solutions.
- On-site surveys and water management plans to develop specific water efficiency measures.

The staff of the MWRA's ICI Water Management Program are available to answer questions, and provide additional information. For assistance, please call (617) 242-7110, or write to:

Massachusetts Water Resources Authority
ICI Water Management Program
100 First Avenue, Building 39
Charlestown Navy Yard
Boston, MA 02129

About Water and Wastewater Costs

This Guide's discussions of potential water efficiency measures include sample calculations to provide examples of the water and wastewater savings that can result. For the purpose of illustration, cost calculations are based on an assumption that the combined water/sewer rate is $7 per 1,000 gallons of water purchased, the representative rate for the MWRA service area as of 1994–1995. The rate for your facility may be higher or lower because water and sewer rates are set locally by municipalities and therefore may vary considerably among communities.

How To Develop A Water Management Plan

A Water Management Plan is developed by you and your staff as an action program for efficient use of water at your facility. As shown in the adjacent illustration, the plan is more than just data gathering and goal setting. A successful plan develops management support, incorporates an employee awareness program, and includes efforts to publicize your successes.

These key components of a Water Management Plan are described in the following paragraphs.

Components of a Water Management Plan

- Obtain Management and Employee Support
- Take Inventory of Water Uses
- Know Your Water-Related Costs
- Identify and Evaluate Water Efficiency Measures; Prepare an Action Plan
- Implement the Plan
- Track and Report the

Step 1: Obtain Management and Employee Support

The first step of a successful program depends on getting full management support for improving water-use efficiency. This should include the facility's upper management, such as the Plant Manager, General Manager or company President. Key personnel involved in finance, such as the Comptroller, may play major roles in approving capital funds for water efficiency projects and should also be involved at the outset.

The most obvious benefit to a company is reduced operating costs from savings on water, sewer, energy, and chemical treatment. Another potential benefit is enhancing the company's image in the community as an environmentally responsible facility.

Once you obtain top management support, demonstrate your commitment by writing a brief policy statement regarding water use efficiency for management to share with your employees. A typical example of a policy statement is shown below:

> *Water conservation is encouraged not only at work, but also at home for our employees. To this end, the company is committed to developing and maintaining a comprehensive water-saving and management program which will ensure our continued ability to grow as well as to provide an increased dollar-saving potential.*

It is important to explain to the employees the reasons that the facility is undertaking a water efficiency program, and to remind the employees that their efforts are the key to the success of the program. Some employees may, at first, not support the program because of concerns about changes in operations. You should be prepared to respond to these concerns and explain to the employees the program's benefits.

Attention to water management must be a part of employees' standard operating procedures. Employees play the key role in detecting leaks or other unusual uses of water. Also, an employee suggestions program with modest rewards for successful water efficiency ideas could also be implemented.

WATER USE CHECKLIST

Domestic/Sanitary Uses

- *Toilets* ❑
- *Urinals* ❑
- *Faucets* ❑
- *Showers* ❑

Cooling

- *Once-through cooling* ❑
- *Chilled water-loop* ❑
- *Cooling tower* ❑
- *Evaporative condenser* ❑

Boiler/Steam Systems

- *Boiler* ❑
- *Blowdown cooling* ❑

Kitchens

- *Dishwasher* ❑
- *Garbage disposer* ❑
- *Scrapping trough* ❑
- *Ice machine* ❑
- *Meal preparation* ❑
- *Steam table* ❑
- *Clean-up/sanitation* ❑

Laundry ❑

Landscape Watering ❑

Process Uses ❑

STEP 2: TAKE INVENTORY OF WATER USES

Before you can write your water management plan, you must know how — and how much — water is used at your facility. To determine this information, perform a facility walk-through to inventory your total annual water consumption indoors by type of use. The walk-through should be done by someone (such as the Plant Engineer) who is familiar with each area of the facility. During the walk-through, speak with the operating personnel in each area to find out specifically how they use water, and to obtain their suggestions. The best ideas often come from those who are most directly involved in the uses of water.

A checklist of potential water uses to look for during the walk-through is presented in the adjacent table.

The end result of the inventory should be a "water balance" that lists and quantifies individual items of water use. This requires measurement or estimates of two factors for each item: flow rate and duration of flow.

- **Measure/estimate flow rates.** A variety of easy techniques can be used to measure flow rates. Water that flows in an open stream, such as the discharge from the end of a pipe, can be collected in a container and measured and timed. Such a container might be a bucket, can, or plastic bag. Plastic bags specifically for this purpose are available; an example is illustrated in Figure 1. These bags are preprinted with markings to indicate the flow rate, based on the volume collected in the bag for a 5-second duration of flow.

Flow rates can be estimated based on the equipment manufacturer's recommendations. This is somewhat useful for completing a water use inventory, but not for identifying water efficiency measures. If you assume that the equipment's design flow rate is being used, you also are assuming that the equipment is using the correct amount of water. In many cases, the flow rate through water-using equipment as it is actually installed and operated exceeds the manufacturer's specifications by a large margin. For example, the manufacturer's specifications for a water-cooled ice-making machine might require a flow of 2 gallons per minute (gpm) of once-through cooling water. Based on the installation and plumbing for the unit, it might

actually use as much as 5 gpm or more. Assuming that the machine uses the manufacturer's specified flow rate, an error in the water balance would result and cause you to miss a significant water savings opportunity.

If you do use this approach, check the equipment nameplate for helpful information. A generic illustration of a typical nameplate is presented in Figure 2. In some instances, the nameplate may list the design flow rate. At a minimum, the nameplate provides identifying information that can be used to obtain the equipment's water requirements from the manufacturer.

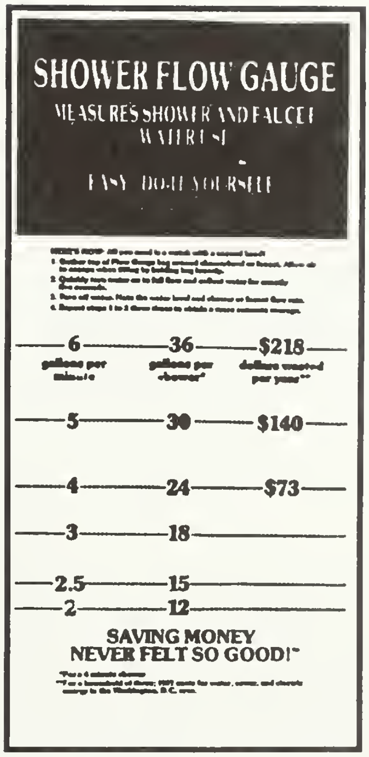


FIGURE 1. *Flow Measurement Bag*

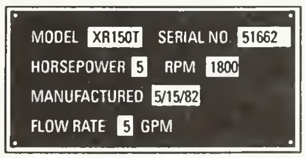


FIGURE 2. *Equipment nameplate*

It is considerably more difficult to determine flow rates for water moving through enclosed pipes. If a process or item of equipment uses a significant volume of water, you should install a permanent submeter to measure the flow. Guidelines for submetering are presented on page 10. To temporarily measure flow in enclosed pipes for your water use inventory, some non-intrusive flow meters are available. These meters are equipped with a sensing device that straps onto the pipe and obtains its readings based on reflection of ultrasonic waves that the device beams into the liquid flowing through the pipe. Unless a large number of measurements are planned, these meters are generally expensive to purchase or rent. Also, their accuracy range is limited, with minimum flow rates that exceed the rate of many individual commercial/industrial water flows.

In the absence of actual measurements, it is possible in some cases to calculate water consumption based on other operating characteristics of the system. An example is the calculation of cooling tower evaporative loss presented in Appendix 4.

- **Determine duration of flow.** Almost as important as the flow rate is the determination of the length of time the water flows at that rate. Calculation of an accurate water balance requires accurate estimates of operating hours for the water-using item. Seasonal variations (such as summer months when a cooling tower serves an air conditioning system) must also be considered. It is also important not to overlook the number of operating days per week or month. For example, if the facility operates five days per week, 52 weeks per year, average water use per weekday should be multiplied by 260, not 365, to determine annual consumption.

After the items have been quantified, you should prepare a summary, or water balance, to compare the total of individual water uses to the actual volume of water metered into your facility. It is likely that the total of individual water uses will not precisely equal the facility's metered water consumption. The difference between metered consumption and the water balance total is referred to as "unaccounted-for water." A small amount (10

percent or less of the total) of unaccounted-for water is to be expected, since it is not feasible to precisely measure each water use's flow and duration. If, however, the unaccounted-for water in your balance exceeds 10 percent, you should investigate further. You have either missed something or there is an undetected leak.

A worksheet you can use to compile the water balance is included at the end of this Guide in Appendix 2 and an example is presented below.

EXAMPLE: *An ice-making machine's refrigeration system is cooled by a stream of once-through water which is discharged into the sewer. The flow rate of the cooling water is measured to be 2.5 gallons per minute. This flow is observed to occur 50 percent of the time throughout the 24-hour day. Calculate the volume of cooling water consumed by the ice-machine.*

Volume = (0.50) x (24 hour/day) x (60 minutes/hour) x (25 gallons/minute) = 1800 gallons per day.

WATER USE INVENTORY

Item	Location	Flow, gpm	Operating time, Minutes/day	Flow/day gpd	Remarks
Toilets	Restrooms	4 gal/flush	1120 flush/day	4,480	
Urinals	"	3 gal/flush	370 flush/day	1,110	
Faucets	"	2.5 gpm	400	1,000	
Ice machine cooling water	Kitchen (2)	2 @ 3.5 gpm	960	6,720	Compressor cycles on/off
A/C cooling water	Computer room	4.5 gpm	1440	6,480	
Dishwasher	Kitchen	3.0 gpm	360	1,080	
Garbage disposer	Kitchen	5.0 gpm	150	750	Estimated flow rate

Step 3: Know Your Water-Related Costs

Understanding the true cost of water use at your facility is a key aspect in developing an effective Water Management Plan. The cost of using water frequently entails more than just the water bill itself. Associated costs often exceed the cost of the water itself, and can include wastewater disposal, energy (for heating, pumping, and treating the water), and pretreatment for some wastewater discharges to the sewer. Sewer charges often are calculated based on metered water consumption, and in those cases, a reduction in water use volume will automatically result in wastewater service charge savings as well.

- **Water and sewer service.** Using your facility's water bills, prepare a summary of the volume and cost of water being consumed. It is strongly suggested that a two-year (minimum) history be reviewed. This will decrease any effects of unusual circumstances (weather or business fluctuations) on the metered water consumption. Because retail water service is provided by individual municipalities, the frequency of meter reading varies among communities, as do units of measure, billing procedures, and rates. The side box provides conversion factors that may be useful in understanding your water bill.

  Understanding the price your facility pays for water is essential to the financial evaluation of proposed water efficiency measures, which will be discussed later in this document. Many different rate structures are employed by water departments. In some MWRA communities, the per unit rates are "flat," and do not vary with consumption, and in others, the per unit rates increase as consumption increases. Your water bill may also include various fixed charges that are independent of the volume of water purchased. Contact your local water department if you do not know how the rates for your facility are calculated.

  At the conclusion of this document, a form is provided for you to record the metered volume and cost data from your water billing statements. A reduced version of this form is shown on the next page.

The Significance of Water Costs:

Even flows which appear small can represent a significant cost over time. For example, consider a continuous flow of 1 gallon per minute (gpm). Over the course of a day, this amounts to 1,440 gallons, and over a year this flow adds up to 525,600 gallons. At the typical water/sewer cost of $7.00 per 1,000 gallons mentioned earlier, this apparently small 1 gpm flow costs $3,680 per year.

Conversion Factors for Units of Volume

1 cubic foot = 7.48 gallons
(cf or cu ft) (gal)

100 cubic feet = 748 gallons
(hcf or ccf or "unit") (gal)

1,000,000 gal = 133,690 cf
= 1,336.9 hcf

Water Consumption Summary									
Period Ending	Days in Period	Acct No. 42-0056 (Description)		Acct No. 42-0057 (Description)		Acct No. 42-0058 (Description)		Total	Average per Day
		Reading	Consumption	Reading	Consumption	Reading	Consumption		
Feb 2 '93		2315920		8724360		4215180			
Apr 5 '93	62	2472180	156,260	8819590	95,230	4267440	52,260	303,750	4,899
Jun 7 '93	63	2667510	195,330	8919490	99,820	4317180	49,740	344,890	5,474
Aug 10 '93	64	2843300	175,790	9027220	107,810	4372000	54,820	338,420	5,288
Oct 4 '93	55	2992720	149,420	9128560	101,340	4422430	50,430	301,190	5,476
Dec 7 '93	64	3119730	127,010	9217740	89,180	4466310	43,880	260,070	4,064
Feb 7 '94	62	3265790	146,060	9302560	84,820	4509200	42,890	273,770	4,416

When you look at your water billing history, check for trends and patterns, such as a seasonal variation in water consumption, a long-term change in the average volume consumed, or a sudden unexplained increase in consumption (which would probably be the result of a leak). These trends can give you helpful clues in analyzing your facility's water use.

Other water-related costs should not be overlooked. The following are some possibilities:

- **Energy Costs.** For some uses of water, energy costs can be significant (see Figure 3). Obvious examples would be any use of hot water or steam produced at the facility. Other water use-related energy costs include pumping and power for water treatment equipment.

- **Chemical Costs.** Water used for some purposes (for example in cooling towers) is chemically treated at the facility, and the chemical cost can in these cases be very significant. The cost of chemical treatment for cooling towers serving a medium-sized office building is in the range of $5,000 to $10,000 per year.

- **Waste pretreatment.** Some industrial wastewaters require pretreatment to remove pollutants before discharge to the sewerage system. The cost of industrial waste pretreatment can be high, and therefore, facilities have a strong incentive to reduce the volume of water associated with uses for which pretreatment ultimately will be necessary. For information on fees charged by MWRA's Toxics Reduction and Control Program (TRAC), please see Appendix 3 at the end of this document.

Cost to Heat Water

Cost per 1,000 gallons

Heated Water Temp., °F	Electr.	Natural Gas	Heating Oil
120	11.00	2.63	3.00
140	14.66	3.50	4.00
160	18.32	4.38	5.00
180	21.98	5.25	6.00

Note: Costs based on unit prices of $0.09 per kWhr, $0.42 per therm, and $4.80 per MBtu of heating oil.

FIGURE 3.

- **Future cost increases.** Facility managers should bear in mind when considering an investment in reduced water consumption that the financial savings are likely to increase in the future as water and sewer rates in the MWRA service area increase.

- **Read meters.** In some communities, meters may not be read as frequently as is desirable for tracking water consumption. Therefore, facilities should read their own meters themselves on a regular basis. Recommended meter reading frequencies are listed in the side box. Further information on meter reading is included in the Maintenance chapter, later in this Guide, and in Appendix 1 at the conclusion of this document.

- **Submeter significant water uses.** Further understanding can be gained by directly submetering the significant water uses in your facility. Submetering means installing a meter to record the volume of water used by a particular item or activity. For example, the make-up water to a cooling tower could be submetered. Submetering should be considered for any item that consumes more than 5,000 gallons per day (gpd). The cost of a meter varies based upon type, size and quality.

  The data obtained from submetering will give you an accurate understanding of the amount of water being used in various areas and help to optimize the water use. One of the biggest benefits of submetering is the opportunity to quickly identify and respond to water losses from leaks and equipment malfunctions.

  Another possible advantage of submetering is the opportunity to document water volumes that are not discharged to the sewerage system. Although policies vary among communities, many local water departments will reduce sewer bills if the facility can prove (by submetering) that a particular volume of water is not discharged to the sewer. Possible examples would be water lost to evaporation from cooling towers, water used as an ingredient in products, or water used for landscape watering. Please note that this is a matter of local policy and varies among communities. You should check with your local water department to determine what its procedures are.

RECOMMENDED METER READING FREQUENCY

Consumption	Read Meters
< 1 MG/yr	Monthly
1 to 7.5 MG/yr	Weekly
> 7.5 MG/yr	Daily

EXAMPLE: *One facility in Cambridge that submetered its cooling towers was able to discover that a broken valve was causing a constant overflow from the cooling towers, within three weeks of the problem's occurrence. Without a submeter, it is likely that several months would have elapsed before the problem was found.*

Example: *A hotel with 100 showerheads that each use 5 gallons per minute (gpm) is considering replacing the showerheads with ultra-low flow units that use 2.5 gpm. Each shopwerhead is used for 5 minutes per day (365 days per year), and water-related costs as have been described previously. The hotel uses a gas water heater, and the water is heated to 120°F. The new showerheads cost $20, installed. What is the simple payback period for the proposed action?*

Solution. *Do not forget to consider the energy cost of $2.63 per 1,000 gal for gas heating.*

Water Savings =
(5 -2.5) gal/min x 5 min/day x 365 day/year x 100 = 456,250 gal/year

O & M Savings =
(456,250 gal/year) x ($7.00 + 2.63) /1,000 gal = $8,788/year

Capital Cost =
(100) x ($20 each) = $2,000

Simple payback period =
($2,000) /($4,394/year) = .46 year

This would be a very cost-effective action; the simple payback period is approximately 6 months

Step 4: Identify and Evaluate Water Efficiency Measures; Prepare an Action Plan

Once you know how much water your facility is using, you can compare that amount to what is actually necessary for proper operation. Equipment O&M manuals or other similar literature can help you determine proper equipment flow rates. Be sure also to check for water that flows needlessly on off days, during down time, or when equipment is on standby.

Look for ways to reduce water consumption. The next chapter of this Guide offers several specific suggestions, many of which could be applicable to your facility. An action intended to reduce water consumption and costs is referred to as a "Water Efficiency Measure" (WEM).

To evaluate if a potential water efficiency measure is worthwhile, do a cost-effectiveness analysis of each measure individually. This section describes how to perform the analysis.

- **Evaluating Water Efficiency Measures.** For each potential WEM, you must determine the value of the expected water savings. In addition to reducing your water bill, many WEMs provide additional savings on sewerage bills, or through reduced use of energy or chemicals. The savings from implementing a WEM are ongoing, annual savings. In most cases, they will continue to accrue year after year. Sometimes, implementation of the WEM may involve some annual costs. (Obviously, if the annual costs exceed the savings, the WEM is not cost-effective.) The annual savings minus annual costs equal net annual savings.

  A variety of personnel can be involved in the evaluation of a proposed water efficiency measure. Facility personnel who will be working with the modified operation should be given the opportunity to provide comments and suggestions. The quality control staff will need to be assured that reduced water consumption will not detract from the quality of the facility's product or service. Financial staff will be interested in a careful evaluation of the proposed measured cost-effectiveness. The facility's public relations staff should be kept apprised of the water efficiency effort so they can publicize it if appropriate. Finally, customers may be affected by the water efficiency effort. The facility should be prepared to deal with their perceptions and concerns as well. Water efficiency measures are by no means intended to compromise customer service. However, you may find it helpful to notify your customers of your efforts.

To determine whether the potential WEM is a good investment, compare the expected net annual savings to the capital costs. Capital costs are one-time initial expenses, primarily for equipment purchase and installation. Many facilities make this comparison in terms of the "simple payback period," which is the length of time the annual savings must accrue to add up to the capital costs of the action calculated as follows:

$$\text{SIMPLE PAYBACK PERIOD (YEARS)} = \frac{\text{CAPITAL COST (\$)}}{\text{NET ANNUAL SAVINGS (\$/YEAR)}}$$

This calculation is simple to perform, although it does neglect the consideration of interest rates. Most facilities will implement a WEM or other plant improvement if the payback period is two years or less. A sample calculation is illustrated in the side box on previous page.

Other important financial considerations are the capital cost and financing requirements of each proposed water efficiency measure. At some facilities, it is difficult to readily access the funds for WEMs with significant capital costs. For example, many facilities have an annual capital budgeting process and items not in the current capital budget might have to be deferred to the following year. Actions that can be done with in-house personnel and at low capital cost tend to be easier to implement, even if a more expensive action is more cost-effective. Facility managers must weigh ease of implementation against overall savings in developing their water management plan.

A worksheet that you can use to calculate the simple payback period of potential WEMs is included at the back of this Guide in Appendix 2, and is reproduced below for reference.

Water Efficiency Measures (WEMs)							
Water Efficiency Measure	Water/Sewerage Savings		Other Savings $/yr	Annual Costs $/yr	Net Annual Savings $/yr	Capital Cost $	Payback Period yr
	gal/yr	$/yr					
ULF Toilet Replacement	698,880	4,890	–	–	4,890	7,600	1.6
ULF Urinal Replacement	192,400	1,350	–	–	1,350	2,400	1.9
Faucet aerators	195,000	1,370	470	–	1,840	300	0.2
Air-cooled ice machine	1,747,200	12,230	–	850	11,380	5,000	0.4
Connect A/C to chilled wtr	1,684,800	11,790	–	1,100	10,690	3,000	0.3

- Preparing an Action Plan. Commit your water management plan to writing. The plan should describe how you plan to save water, how much water and money will be saved, and who is responsible for carrying out the plan. Begin planning by reviewing the results of your self-audit. Set measurable reduction goals, either by gallons or by a percentage. State where and in what time frame the reductions will be achieved. Include a specific explanation of each task.

  EXAMPLE: *"Increase cooling tower concentration ratio from 4 to 10 using conventional chemical treatment." Then rank each task according to cost-effectiveness, and support high-cost tasks with a cost/benefit analysis.*

  It is important to identify who will be responsible for carrying out your plan's implementation and revision. Annual evaluations are suggested. Be sure to include an awareness program to notify all affected employees (see Step 5). Be sure to distribute the Water Management Plan to all concerned. An example of a Water Management Plan is presented below.

MODEL FOR A WATER MANAGEMENT PLAN

XYZ Corporation
Water Management Plan

				Projected Annual Savings	
Water Efficiency Measures	*Person Responsible*	*Due Date*	*Initial Cost*	*$*	*gallons*
Increase cooling tower concentration ratio from 4 to 10					
Call ABC Chemical Co. with change	Plant Engineer	March 15	—		
Install conductivity meter	Plumber, Electrician	April 30	$3,000		
Install make-up and bleed-off meters	Plumber	April 30	$1,500		
			$4,500	$17,500	2,500,000
Install low-flow showerheads					
Order from EFG Plumbing	Plant Engineer, Purchasing Manager	June 1	$2,400		
Install showerheads	Plumber	July 15-30	$1,800		
			$4,200	$7,500	912,500
Replace water-cooled ice-maker with air cooled model					
Order from HIJ Kitchen Supply		July 1	$4,500		
Install		September 15-18	500		
Start-up		September 18	—		
			$5,000	$3,680	525,600
Employee Involvement Program					
Distribute plant manager memo on water efficiency	Plant Manager	March 1			
Discuss at staff meeting	Plant Engineer, Shift Supervisor	March 15			
Post flyers on employee bulletin board	Employee Relations	Monthly			

Step 5: Implement the Plan

Once the water management plan is in place and approved, act promptly to carry it out. The plan should include a ranking of actions in order of priority for implementation. As noted above, actions with low capital cost and those that can be done in-house are often the easiest to implement. A sensible approach is to begin with the easiest and simplest measures, and progress to the larger items as the water management plan develops some successful results. Examples of easy first-step actions are: reducing the flow rates through water-cooled equipment, and placing dams in all toilet tanks. These have little or no cost and can be done with the facility's own personnel.

A water management plan that employees are not aware of or do not support will fail. It helps to build employee awareness by including incentives (no matter how small) that recognize staff for using water efficiently. Some ideas for you to choose from include:

- Conduct regular staff meetings to communicate your water management plan and water savings progress. Ask employees to develop a slogan to help create ownership and draw attention to the plan.

- Establish a reporting system for leaking faucets, toilets, sprinkler heads, and other forms of water waste. Be sure to respond to leaks promptly.

- Use employee publications and paycheck inserts to communicate information.

- Encourage employees to develop their own ideas for water efficiency; then recognize innovative suggestions. Awards can range from special recognition, such as a picture in the company newsletter to cash and benefit incentives.

- Post plan-related information and progress reports in employee cafeterias and break rooms as reminders. Notify employees as major goals are reached.

- Help employees increase their water management awareness at home, too.

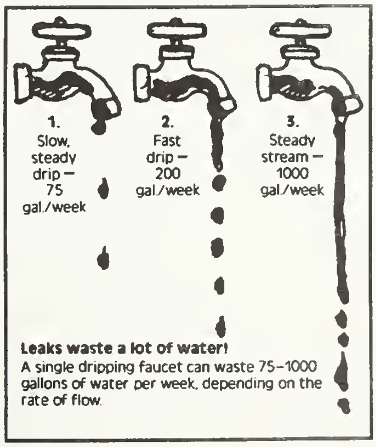


Figure 4. *Water loss rate from leaks of various sizes.*

EXAMPLE: *a Cambridge manufacturing facility meters its water consumption daily and posts the results on a bulletin board, including a comparison to similar previous time periods.*

STEP 6: TRACK AND REPORT THE RESULTS

It is a good idea to review and update your Water Management Plan annually, or sooner if you decide it is best for your facility.

- Graph the facility's water consumption to identify trends. Post a bulletin board or marking board where the plan's results can be tracked and communicated to the employees.

- Record successful efforts. Each water efficiency measure's results should be tracked and reported to the personnel involved. Results should include both water and dollar savings.

- Analyze efforts that have not been successful and try to figure out what modifications might work.

- Let your employees know how the plan is doing and how proposed changes will affect them. Schedule a meeting to discuss the plan and solicit their input.

When your plan has resulted in significant water savings, publicize your success.

- Run an article in the company newsletter.

- Include the results in the corporate annual report.

- Develop press releases for local media.

- Create a display for the lobby of your facility.

- Make presentations at trade organizations, or publish articles in trade publications.

- Use this as an opportunity to publicize your facility's positive contribution to the environment.

Water Efficiency Measures

This section describes Water Efficiency Measures applicable to the most common water uses at businesses, industries, and institutions, in the following categories: Domestic/Sanitary, Cooling Purposes, Boilers and Steam Systems, Kitchens, Laundries, and Clean-up/Sanitation.

Domestic/Sanitary Uses

Domestic/ sanitary uses include toilets, urinals, lavatory faucets, and showers. Information sheets presenting data information collected by MWRA about water-efficient plumbing fixtures are presented at the conclusion of this document.

The Commonwealth of Massachusetts plumbing code requires that all new plumbing fixtures be of the ultra-low flow type, as summarized in the side box. Similar plumbing fixture efficiency standards enacted by Congress in 1993 will soon apply nationwide.

Many options are available to improve the water- efficiency of the plumbing at existing facilities. Possible water efficiency measures range from retrofitting fixtures with inexpensive devices, to entirely replacing the fixtures with low-flow units. Some of the opportunities available are described below.

Toilets and Urinals. There are two basic types of toilets: flushometer valve type and tank type. A flushometer valve, the more common type in public and commercial settings, includes a diaphragm valve which is opened to let in a rapid stream of water at full line pressure. In a tank toilet, which is the type most commonly found in residential settings, flush water is stored in the tank and released for flushing by the lifting of a flapper valve in the tank.

- Toilets and urinals equipped with flush valves can be retrofitted with orifice inserts or valve replacement kits to reduce the volume of water used per flush. Certain more recent flush valves have reversible rings inside which when turned over and replaced will reduce the flushing volume.

- Consider replacing existing toilets and urinals with new ultra-low flush (ULF) models. ULF toilets use 1.6 gallons per flush or less; ULF urinals use 1 gallon per flush or less. Only ULF toilets and urinals may be used in new construction.

- If you have tank-type toilets, do dye-tablet tests once every six

Commonwealth of Massachusetts Flow Standards for New Plumbing Fixtures

Item	*Standard*
Toilets, gals. per flush	1.6
Urinals, gals. per flush	1.0
Lavatory faucets, gal. hot water per minute	0.5
limit per use, gal.	0.25
Shower heads, gals. per minute	3.00

Water Conserving Plumbing Fixtures Capital Costs

Item	*Cost Range*
Kitchen faucet	$120-260
Lavatory faucet	$130-170
Lavatory faucet, metering type	$120-210
Faucet aerator	$5
Showerhead	$8-20
Toilet (ultra-low flow 1.6 gal. per flush)	$100-600
Tank toilet retrofit kit	$15
Urinal flush valve	$100
Urinal fixture	$190-440
Flushometer valve replacement kit	$20
Flush meter orifice insert	$3
Infrared faucet control	$380
Infrared toilet/ urinal control	$340

EXAMPLE: *A college athletic center retrofitted 18 wall-mounted flushometer toilet fixtures, saving 1 gallon per flush (gpf). For an installed cost of $400, the retrofitted fixtures save 164,000 gallons per year, or $750 per year. The simple payback period for this action was 6 months.*

months on all of them to check for leaks. Place the dye tablets in the toilet tank, wait a few minutes without flushing, and see if the color appears in the bowl. If so, there is a leak. A few drops of food coloring may be used in place of the dye tablets. Repair each leak that is found.

- Retrofit tank-type toilets with dams or water-filled plastic containers as displacement devices to reduce the volume of water used per flush. Do not use a brick for this purpose; it may decay and damage your plumbing.

Faucets.

- Retrofit faucets with aerators to add air to the flow stream and reduce water usage. Many faucets with aerators consume as little as 1.0 gpm. Tamper-proof aerators are available and should be used at sites where vandalism is a potential problem (for example, schools).

EXAMPLE: *A water management study of a hospital in Stoneham found that the facility had 361 flushometer toilets, using an average of 4.5 gallons per flush (gpf). If the facility opted to replace all of the toilets with new ultra-low flush (1.6 gpf) models at $181 per unit, the total implementation cost is approximately $65,300, including labor. Based on an estimated 14 flushes per day, the annual savings would be $42,300, resulting in a simple payback period of 1.5 years.*

- Change to alternative faucets that control the duration of flow and prevent water from running when not in use. Buildings with heavy public traffic are particularly appropriate for these faucets. Such facilities include schools, theaters, museums, and public agency offices. There are three types of faucets which can be considered: metering faucets (which stay open a pre-set period of time and then close), self-closing faucets (which close as soon as the user releases the knob), and automatic sensor-controlled faucets. One of the disadvantages of metering faucets is that accumulated sediment can interfere with the workings of the spring-loaded closing device. The result is that the faucet can actually stay on longer than is necessary. Metering faucets should be checked periodically to be sure that they are closing properly.

- Reduced use of hot water by faucets will result in energy savings as well as water/sewer savings. Often, the financial value of the energy savings is even greater than the financial value of the water savings.

Showerheads. Water efficiency measures for showerheads will result in energy savings as well, and therefore additional cost reductions, as was illustrated previously.

- Retrofit showerheads with new water-conserving hardware or aerators. A water-conserving showerhead should use 3.0 gallons per minute or less and will also save energy by reducing hot water consumption.

- Install individual valves on showers that have one valve operating several showers at once.

Water for Cooling Purposes

Once-through Cooling. Eliminate all uses of water for once-through (or "single-pass") cooling. Once-through cooling is the practice of running water continuously through an item requiring cooling, with the water going directly to a drain for disposal. As was previously illustrated, even a comparatively small flow rate can add up to a large volume and major expense for every item that is cooled by single-pass water.

The MWRA and many other sewerage regulations prohibit the discharge of uncontaminated once-through cooling water to the sewerage system. Legal and cost issues make it imperative that once-through cooling be eliminated wherever possible.

Possible locations where once-through cooling water often is found include:

- Ice Machines
- Refrigeration Systems
- Air Conditioners
- Process/ Lab Equipment
- Air Compressors
- Process Tanks/Baths

Several actions can be taken to eliminate once-through cooling.

- Air-cooled models can replace many items of water-cooled equipment. For example, air-cooled ice machines can be installed in place of water-cooled models.
- Connect to a recirculating cooling water loop (such as a chilled water system, if present) instead of using once-through cooling.

Cooling Towers. Cooling towers are a much more water-efficient method of providing cooling compared to the once-through approach. Despite their water-efficiency, cooling towers often are the largest user of water in industrial plants, office buildings, hospitals, and other facilities with large

Example: *An athletic facility retrofitted 35 showers with new showerheads to reduce the flow rate from 4.0 to 2.5 gallons per minute. For an initial investment of $330, annual savings are 328,000 gallons and $3,330 (including energy conservation from reduced consumption of hot water), a payback of 1 month.*

Example: *A full-service restaurant that has once-through water-cooled refrigeration units and ice machines is converting to air-cooled condensers. The annual water savings totals 1.5 million gallons. The net annual cost reduction was $8,900. For an initial investment of $11,100, the payback period is 1.3 years.*

EXAMPLE: *A hospital in Boston eliminated single-pass cooling of eight refrigeration units by installing a closed-loop fluid cooler. The heat from the equipment is transferred to a circulating glycol/water solution, and then rejected to the atmosphere. Annual water savings totalled 3.2 million gallons. Net annual operating cost savings were $21,300. For an investment of $29,300, the payback period was 1.4 years.*

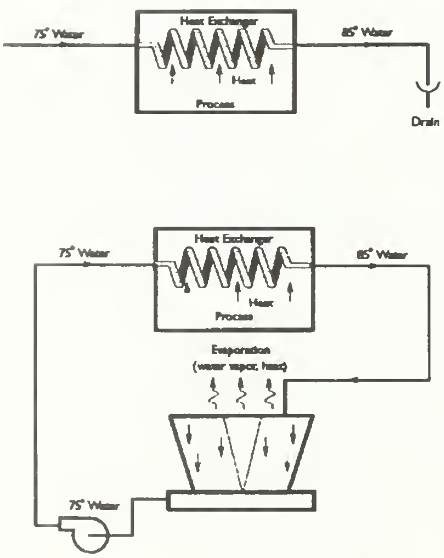


FIGURE 5. *Schematic: comparison between once-through cooling and cooling tower system.*

air conditioning or cooling loads. By understanding the principles on which cooling towers operate and the wide array of water quality management techniques, you can best tap the savings potential for your specific facilities.

The basic function of a cooling tower is to use evaporation to cool a recirculating stream of water. The water circulates to equipment that needs cooling (such as an air conditioning system). A heat exchange occurs: The equipment is cooled, and the water becomes warmer. The loop of water, illustrated at left, is continuously flowing from the cooling tower to the equipment to be cooled, and back again.

Figure 5 shows how a cooling tower works in comparison to once-through cooling. Water droplets or sprays travel against an air flow, causing a portion of the water to evaporate. This cools the water that remains behind.

The evaporation rate varies depending on the amount of cooling achieved, and to a much lesser extent, weather conditions. Water that evaporates from a cooling tower is pure vapor. The dissolved solids in the water supply remain in the cooling system and concentrate in the recirculating water. As pure water continues to evaporate, the concentrations of the dissolved solids increase in the water circulating through the cooling tower system.

If dissolved solids are not limited to a reasonable level by the cooling tower operator, their concentrations can reach levels that seriously damage the system. The potential water quality problems include scale, corrosion, and biological fouling. In most systems, dissolved solids are removed by releasing, or "bleeding off," a portion of the recirculating water. The solids dissolved in the bleed-off water are carried out of the system. The flow of bleed-off water is usually controlled by timers, conductivity meters, or manually. Bleed-off usually is the only use of water in a cooling tower that can be reduced as a conservation measure.

Makeup water is the water added to the cooling tower to replace water lost to evaporation, drift, and bleed-off. Figure 6 presents a schematic diagram illustrating the uses of water in a cooling tower. The relationship between the concentration of dissolved solids in the cooling tower and in the make-up water is known as the "concentration ratio," or "cycles of concentration." The definition is expressed in the following equation:

$$\text{CONCENTRATION RATIO} = \frac{\text{CONCENTRATION OF COOLING TOWER WATER}}{\text{CONCENTRATION OF MAKE-UP WATER}}$$

Decreasing the amount of bleed-off, with evaporation remaining constant, will result in a higher concentration ratio. Figure 7 illustrates the relation-

ship between concentration ratio and total water consumption. As the concentration ratio (shown on the horizontal scale) increases, the total water consumption (shown on the vertical scale) decreases. Within the MWRA service area, concentration ratios typically range from values of 6 to 12.

Significant reductions in water consumption can be made by increasing the concentration ratio if you have previously been operating at a concentration ratio of about 6 or less. If the concentration ratio is 10 or greater, only a small additional amount of water can be conserved. The reason is that cooling towers operated at these high concentration ratios lose 90 percent or more of the water consumed to evaporation, which cannot be reduced. Figure 8 provides a chart to determine the percentage of water savings you can achieve from increasing the concentration ratios at which a cooling tower operates.

In evaluating a cooling tower system, it must be noted that the concentration ratio is not the sole criterion of appropriate performance. Source waters with higher TDS concentrations will result in higher concentrations in the recirculating water in a cooling tower system. Therefore, proper management of cooling water includes examination of the specific constituents of the water and their potential for causing scaling and other problems.

It may be advisable to consult with one of the many qualified water treatment chemical suppliers or equipment vendors offering their services in your area.

Water Conservation Opportunities

Water conservation for a cooling tower results from reduced use of water for bleed-off. In addition to these savings, wastewater service charges can also be decreased because of the lesser volume of bleed-off discharged to the sewer. Another potential savings, which sometimes is overlooked, is decreased chemical consumption.

Methods used to prevent scale formation include chemical treatment with scale inhibitors (such as organophosphates), and bleed-off to reduce the mineral concentrations. Corrosion and biofouling can be controlled by the use of corrosion inhibitors and biocides, respectively. These chemicals are added into the recirculating water by automatic feeders, which may be controlled based on the conductivity of the water, the volume of make-up water added to the system, or by timers. Most facilities contract with a commercial water treatment firm to supply the chemicals and manage their use.

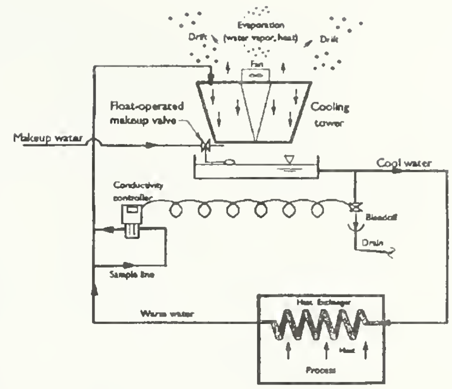


Figure 6. *Schematic: Cooling tower water uses.*

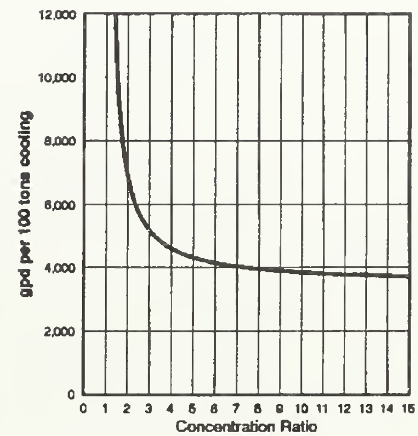


Figure 7. *Relationship between concentration ratio and cooling tower water consumption.*

Water savings from increas[illegible] concentration ratios

Concentration ratio before	Concentration ratio after: 2	3	4	5	6	7	6	9	10	12	15	20
1.5	33%	50%	56%	58%	60%	61%	62%	63%	63%	64%	64%	65%
2		25%	33%	38%	40%	42%	43%	44%	44%	45%	46%	47%
3			11%	17%	20%	22%	24%	25%	26%	27%	29%	30%
4				6%	10%	13%	14%	16%	17%	16%	20%	21%
5					4%	7%	9%	10%	11%	13%	14%	16%
6						3%	5%	6%	7%	9%	11%	12%
7							2%	4%	5%	6%	8%	10%
6								2%	3%	5%	6%	8%
9									1%	3%	5%	6%
10										2%	4%	5%
12											2%	4%
15												2%

Figure 8. *Water savings (%) from increased concentration ratios.*

In addition to the water quality problems described above, many types of foreign matter, such as dust and oil, can become entrained in a cooling water system. The primary source of foreign matter is airborne pollution. These contaminant particles increase the turbidity of the cooling water, and can clog the water distribution systems, obstruct passages in the fill, and settle out in low velocity areas, making frequent cleaning necessary.

Many alternative products and services are available for cooling tower water management. Be aware that many products are marketed with exaggerated or unfounded claims about their effectiveness or safety. Be sure to deal with reputable suppliers, whose claims are reasonable and verifiable.

- **Monitoring.** Proper maintenance of the cooling tower is essential, not just for water efficiency, but also to protect the tower and prolong its life. The performance of the cooling tower system should be monitored and the data recorded and reviewed, to ensure efficient cooling performance and for water conservation.

To assist in recording and analyzing data, two different logsheets (A and B) and instructions on their use are provided in the Appendices, and samples of the completed worksheets are reproduced here.

COOLING TOWER LOG SHEET "A"

Cooling Tower T-2 Capacity 150 tons Location Roof @ stairwell
Meter Units gal

Date	Makeup Meter Reading	Makeup Water Consumption, M	Bleed-off Meter Reading	Bleed-off Water Consumption, B	Evaporation E = M - B	Concentration Ration CR = M/B	Remarks
4-18-93	2521400		452400				end of shutdown
5-3-93	2536100	14,700	453630	1230	13470	12.0	
5-17-93	2554300	18,200	455200	1570	16630	11.6	
6-2-93	2582780	28,480	457760	2560	25920	11.1	
6-16-93	2617640	34,860	460980	3220	31640	10.8	

COOLING TOWER LOG SHEET "B"

Cooling Tower T-2 Capacity 150 tons Location Roof @ stairwell
Parameter Measures gal Units

Date	Makeup Concentration	Bleed-off Concentration, CB	Concentration Ratio, CR = CB/CM	Cooling Load, 100's of tons	Minutes per day, min/day	Evaporation, gpd E = ~~2.4~~ 3.0 x (load) x (min/day)	Bleed-off, gpd B = E/(CR - 1)	Makeup, gpd M = B + E	Remarks
4-18-93	95	1100	11.6	40	600	720	70	790	restart for Summer
5-3-93	85	1050	12.4	60	600	1,080	90	1170	
5-17-93	90	960	10.7	60	720	1,300	130	1430	
6-2-93	90	1010	11.2	90	720	1,940	190	2130	
6-16-93	95	1040	10.9	120	720	2,590	260	2850	

(Monitoring Continued)

- Prepare an inventory of each cooling tower you have, its cooling capacity, and the equipment or processes that it serves. Meter and record the amount of make-up water added to each tower, and the amount of bleed-off water discharged from each tower.

- **Decrease Bleed-off.** Reduce the amount of bleed-off discharged from the system to the minimum level consistent with good operating practice. Bleed-off is the release of some of the circulating water to remove suspended and dissolved solids. Reducing the amount of bleed-off is usually accomplished by treating the cooling water by physical or chemical means to enable more recirculation through the system.

- **Conductivity Control.** Because conductivity is an indicator of the concentration of dissolved solids in the system, a conductivity meter can be incorporated in a control unit to regulate the discharge of bleed-off from the cooling tower. This is a commonly used practice and is far superior to the use of manual bleed-off control. Using a conductivity controller will result in bleed-off being discharged only when the concentration of solids in the system exceeds a pre-set desired level.

- **Work with Your Vendor.** If you are using conventional water treatment, work with your chemical vendor to increase your cycles of concentration, thereby decreasing the amount of water bled off.

  When purchasing chemicals for treating the recirculating cooling tower water, have the chemical vendor explain the purpose and action of each chemical. Your chemical vendor should provide a written report of each service call. Be sure that the vendor explains the meaning of each analysis performed, as well as the test results.

  Tell your chemical vendor that water conservation is a priority at your facility, and ask about alternative programs that could reduce the amount of water bled-off from the towers.

  Establish a performance-based specification, and have vendors make proposals for your facility's cooling tower water treatment. Require that vendors commit to a predetermined minimum level of water-efficiency. Have them provide figures showing projected annual water and chemical consumption and costs.

EXAMPLE: *A beverage plant with a 120 ton cooling tower added make-up water to the tower through a valve at a constant rate of 4 gallons per minute (gpm). This resulted in the discharge of an excessive amount of bleed-off. By installing a new make-up water valve and conductivity controller at a cost of $3,500, 75 percent of the make-up water flow was eliminated for annual water savings of 1.6 million gallons. The resulting cost savings were $11,200 in reduced water and sewer charges, and $3,200 in reduced chemical consumption for a total of $14,400 per year. The payback period was 3 months.*

- **Ozone Treatment.** Ozone is a possible method of cooling water treatment. Ozone is a powerful biocide, and is sometimes used as an alternative to chlorination. In a cooling tower ozonation system, a sidestream of the tower water is passed through an ozone contactor. The ozone is generated on site by passing air or pure oxygen through an electric field. A number of vendors offer ozonation systems for cooling tower water treatment, and some claim that ozone can also prevent scale and corrosion. Figure 8 presents a schematic diagram of a cooling tower ozonation system.

  The success and potential water savings of ozone depend upon the existing system and the application. Ozone is a powerful oxidizer and has been reported to attack system materials of organic origin (wood, certain types of rubber) when over applied. Observe the appropriate safety precautions in handling and working with ozone.

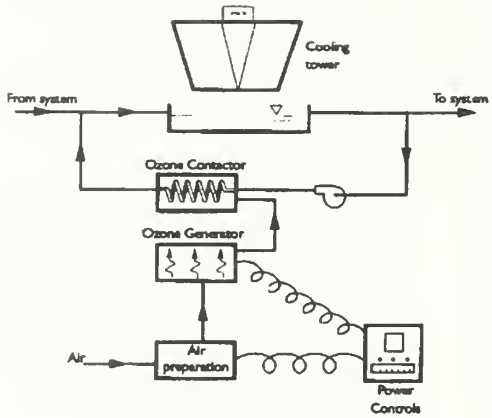


FIGURE 9. *Schematic: Cooling tower ozonation*

BOILERS AND STEAM SYSTEMS

Boilers and other sources of steam are commonly used in large heating systems or at facilities where large amounts of process heating are used. Figure 10 presents a schematic diagram of the uses of water in a boiler system.

Water consumption rates of boiler systems vary depending upon the size of the system, the amount of steam used, and the amount of condensate return. Water is added to a boiler system to make-up for the water losses, and to replace water lost when the boiler is blown down to expel any solids that may have built up. The water in the boiler is treated with various chemicals to inhibit corrosion and scale formation in the steam distribution system. Conserving water in steam systems will reduce water, energy, and chemical purchase costs.

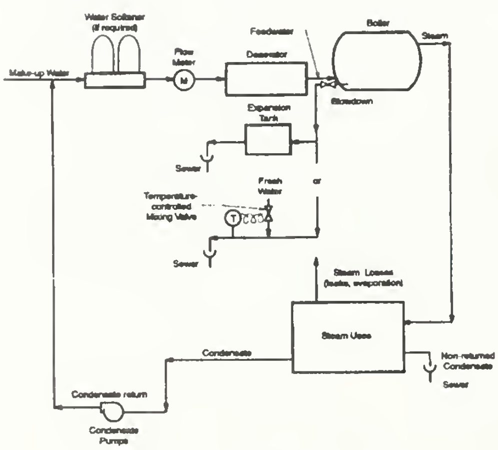


FIGURE 10. *Schematic: Boiler/steam system*

- Recover steam condensate and return it for reuse as system make-up water. Water use, energy, and chemical consumption will be reduced by installing a condensate return system. Energy is conserved because the returned condensate is still warm and requires less heating than incoming City water. Condensate return may reduce operating costs for a steam system by up to 50 to 70 percent.

- Steam traps and lines should be checked for leaks and repaired as soon as possible. Steam traps are an important component of a steam system's efficiency. Old or worn traps allow steam

to escape without providing benefit to the system. This wastes both water and energy. Most steam traps can be easily repaired by plant operations personnel with replacement kits available from the manufacturer.

- Steam and condensate piping should be insulated to conserve heat energy and reduce steam requirements.

- Limit the amount of blowdown to match water quality requirements. Check continuous blowdown systems to be sure that an excessive amount of water is not being discharged from the system.

- Blowdown should be discharged via an expansion tank allowing it to condense and cool. Avoid the use of cold water mixing valves for blowdown cooling; if your facility does have such mixing valves, check them to be sure that the water does not flow continuously and consider replacing them with an expansion tank.

Kitchens

Many facilities have kitchens and cafeterias. Kitchens are generally equipped with dishwashing machines and garbage disposers, and ice makers, all of which are major water-consuming appliances. Water is also used in various other steps during food preparation, sanitation, and clean-up.

Dishwashers

- Improve water efficiency by operating dishwashers properly, washing full loads, and using water flow rates no greater than those specified by the manufacturer.

- Many dishwashing workstations have a pre-wash spray fixture to rinse plates before washing. Flow rates discharged from these units should be reduced to the minimum necessary. Also, spray rinse fixtures are often subject to hard use and frequently develop leaks. Leaking fixtures should be replaced.

- Install pressure or flow regulators to limit flow to the manufacturer's specified rate.

- You should be aware that the National Sanitation Foundation (NSF), a private testing institute, has developed listings of dish-

EXAMPLE: *A site visit at an office building in Boston found a high flow rate of 24 gallons per minute (gpm) through the kitchen scrapper trough. The trough is used approximately 4 hours per day. Facility plumbing staff installed a flow rate limiting device to reduce the flow to 6 gpm. Savings will be over 4000 gallons per day, or 1 million gallons per year. With an installation cost of approximately $280, water and sewer savings are projected to be $8,600 per year, giving a payback period of approximately two weeks.*

washers meetings its certification standards. The NSF listings for dishwashers include specified rinsewater flow rates that the machines are required to use to remain listed.

- Take steps to be sure that the flow of water through the dishwasher stops when the flow of items being washed stops. Although the flow of water in many dishwashers shuts off when the conveyor stops, many times the conveyor continues to move when no dishes are present, and water flows needlessly. Equip conveyor-type machines with sensing arms that detect the presence of dishes moving along the conveyor and control the flow of water accordingly.

- Check your dishwasher to be sure that it is not using an excessive amount of water. Experiment with a modest reduction (about 10 percent) in the flow rate of water to your dishwasher to see if any problems result. If no problems occur, continue to operate at the reduced flow rate. Consult with the equipment manufacturer or your service contractor before making major changes.

- Scrapping troughs, and in larger systems, conveyors are used to convey food wastes and garbage to a garbage disposers. The scrapping system uses a flow of water in a trough. The conveyor system uses a moving belt and does not use any water. Limit scrapping troughs to operate no more frequently than when the dishwasher is in use, and preferably, only when needed. The use of scrapper systems could in fact be eliminated, because it is not necessary to dispose of food waste to the sewer system.

Garbage Disposers

- Consider eliminating the use of garbage disposers. Because it is not necessary to dispose of food wastes to a sewer, the use of garbage disposers could be eliminated entirely. In fact, some schools do not use garbage disposers because they frequently require repair or replacement; by eliminating garbage disposers, you may also reduce maintenance costs.

- Instead of using a garbage disposer, consider installing a garbage strainer. A strainer-type waste collector passes a recirculating stream of water over food waste held in a basket, reducing the waste volume by washing soluble materials and

small particles to the sewer. The water flow rate for these units is approximately half that of typical garbage disposers.

- If removal of the disposer is not possible, control the water flowing to it by a solenoid valve that shuts off the water when the disposer motor shuts off. Many disposers have two water supply lines, one to the bowl and one to the grinding chamber. Be sure to check both.

- Experiment by gradually reducing the flow rate of water through the disposer. If no problems arise, continue to operate at the reduced flow rate.

- Some garbage disposers' controls are set to operate for a preset period every time the disposer is turned on; reduce the run time to reduce water consumption.

Ice-making Machines

There are two ways to approach water conservation for ice-makers: the ice-making process itself, and the cooling of the refrigeration condenser (for water-cooled models).

- Water-cooled ice makers can be retrofitted to be cooled by the facility's chilled water system, if available, or by remote air-cooled condensers. These retrofits of ice machines are relatively inexpensive and have quick payback periods.

- Alternatively, water-cooled ice makers can be replaced with air-cooled units. Because the useful life of ice makers can be as short as five years, replacing existing water-cooled ice makers with air-cooled models can be completed within a relatively short period. Heat is rejected from air-cooled ice makers as warm air; provisions should be made for this additional heat load. In small spaces, it may not be possible to dissipate the heat from the air exhaust.

- If it is not feasible to immediately replace your water-cooled ice makers, reduce the cooling water flow rate to the minimum necessary, as an interim measure. The cooling water flow rate should be reduced to the point that the water becomes warm before being discharged.

- Ice flake machines generally use much less bleed-off water than ice cube machines and should be used wherever possible

instead of cube makers. This will eliminate the flow of reject water used by cube machines to maintain cube clarity. Flake ice is chopped in irregular shapes, and clarity is not a consideration. Therefore, no bleed-off water is used to carry off contaminants.

Other Items

- Plan ahead and thaw frozen foods in a refrigerator instead of using running water. If water-thawing is necessary, a running stream of water should be used as required by most local health departments; however, use a slow flow.

- As with ice makers, soft-serve ice cream and frozen yogurt machines are available with two different types of condensers: water-cooled, and air-cooled. Most water- cooled units use a single pass of cooling water. There are three options for eliminating this use of cooling water: (1) as with ice makers, the unit could be replaced an air-cooled model which does not require any water for condenser cooling; (2) the unit could be retrofitted to be cooled by the facility's chilled water system, if available; or (3) cooling could be provided by remote air-cooled condensers.

Laundries

Many facilities operate large laundry operations for linens, uniforms, and other washable items. Typically, water consumption at laundries is in the range of 3 to 5 gallons per pound laundered. New laundering equipment now available is more water-efficient than the equipment used in the past. Although water reclamation equipment is now commercially available for laundries, most laundries have not yet installed it.

- Be sure to wash full loads only.

- Work with your laundry chemical supplier to develop programs requiring fewer rinse and wash steps. By changing chemicals or the washing program, you may be able to eliminate several fills of the washer-extractor for wash or rinse steps. One laundry in Boston reduced its water consumption per pound of laundry by 15 percent, using this approach.

- Save up to 25 percent of your laundry's water consumption by installing a rinsewater reclamation system. These systems pro-

vide computerized control, based on the laundry cycle, to divert rinsewater to a storage tank for reuse as washwater.

- Save approximately 50 percent of your laundry's water consumption by installing a wash and rinsewater treatment and reclamation system. These treat wastewater from the laundry process to make it clean enough for reuse in initial wash cycles. These systems' treatment processes can include a combination of the following: settling, dissolved air flotation, filtration, chemical feed, and carbon adsorption.

- Consider replacing a conventional washer-extractor with a continuous-batch washer which can save 60 to 70 percent of the volume of water and steam required if operated properly. Additional benefits can include energy savings reduced maintenance costs, and reduced chemical usage. Minimize the need for resetting of equipment controls by carefully scheduling loads.

- Some manufacturers now offer laundry systems that employ ozone as a means of improving the efficiency of water and chemical use.

EXAMPLE: *A large commercial laundry installed a continuous-batch washer at a cost of $1 million, resulting in annual water savings of 25 million gallons and operating cost reductions in excess of $500,000 per year from reduced water and sewer charges, improved employee productivity, and decreased chemical consumption.*

GENERAL WASHING AND CLEAN-UP

Water is used in many ways at facilities for general washing and sanitation purposes. These uses can involve excessive quantities if attention is not paid to maintaining reasonably low flow rates.

- Hoses should be equipped with water-efficient high pressure, low-flow nozzles to decrease the volume of water flowing but improve the cleaning effectiveness of the spray. At a minimum, do not leave hoses running when the water is not needed.

- Steam cleaners can be an effective cleaning method for heavily soiled items; a wide variety are available and should be properly selected for the task.

- Clean-in-place (CIP) systems should be designed to recirculate water internally, and again use high pressure and temperature where possible to enhance the cleaning effect. Avoid the use of continually running rinse streams and overflows.

MAINTENANCE

Efficient water management should be a key aspect of regular maintenance procedures at any facility. The previous chapter described various water efficiency measures that can be undertaken to reduce the volume of water used by individual pieces of equipment or operations. This chapter describes activities that should be made a part of the standard operating routine on an ongoing basis, not as a one-time project. The three key aspects are: meter reading, leak detection and repair, and employee awareness.

Employees should be encouraged to report leaks promptly. Any water efficiency measure that is implemented will fail unless the employees are motivated to make it succeed. Employees should frequently be given updates on the progress of the facility's water efficiency program.

Suggestions for employee involvement are presented in the section of this Guide describing water management plans.

Metering

To effectively manage the water used by a facility, it is necessary to quantify the volumes involved. Consequently, frequent reading and recording of water meter data are essential. Regular meter reading can assist in understanding seasonal variations in water consumption, verify the accuracy of water and sewer billings, and help identify the existence of leaks if they occur.

The primary reason that customer meters are installed by water departments is to measure the volume consumed for the purpose of billing the customers for water (and frequently sewer) service. Because the cost of meter reading is substantial for a water department, many departments do not read meters very often. For billing periods between actual meter readings, estimated bills are sent to the customer. Any inaccuracy in the estimated consumption is corrected when an actual reading is obtained by the water department during a subsequent billing cycle. Therefore, the metered consumption data on the facility's water bill can cover such a long period that it is not very useful for anything other than billing purposes.

Facilities should take the initiative to read their own meters. A suggested frequency for meter reading, based on the volume of water typically consumed by the facility, was presented on page 15.

Meter Types

Meters vary in design as well as size. Meters' sizes are described in terms of their inside pipe diameter. Frequently, a meter is sized to match the diameter of the service line carrying water to the customer. There are three principal types of meter which are found at commercial and industrial facilities: displacement, turbine, and compound.

Displacement Meters. In a displacement meter, a positive measurement of the amount of water being delivered is made. A piston or nutating disk with a known volume is moved by the flow of the water, all of which flows through the disk or piston. The number of volumes of the piston or disk that are delivered are counted as individual oscillations of the meter. Displacement meters are very accurate, particularly at lower volumes.

Turbine Meters. A turbine meter measures the flow of water based on the spinning of a multivaned rotor positioned in the flow stream. This does not give a positive measurement of flow; instead, turbine meters are calibrated to register flow based on established relationships between the spin of the turbine and the volume of flow passing through the meter. Turbine meters typically are used for larger volumes of flow. One of the principal drawbacks of turbine meters is that they can be inaccurate under low-flow conditions.

Compound Meters. To combine measurement capability for large volumes and accuracy at low volumes, "compound" meters have been developed. A compound meter combines two meters in one: a large-diameter meter (usually a turbine), plus a small-diameter displacement meter for low flows. When flows are small, they travel through the small displacement meter. As flow rates increase, a "change-over" occurs, and flow diverts through the larger meter. Some compound meters combine the total metered volume on a single register, while other types have a separate register for each of the two individual meters. In these cases, both registers must be read to determine the total consumption.

Figures 11, 12, and 13 at right illustrate the meter types described above.

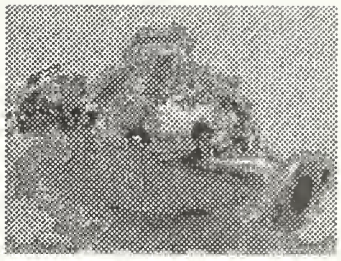


FIGURE 11. *Displacement Meter*

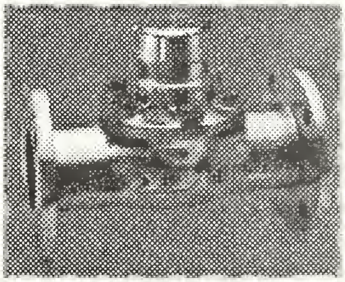


FIGURE 12. *Turbine Meter*

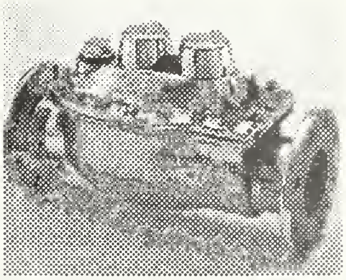
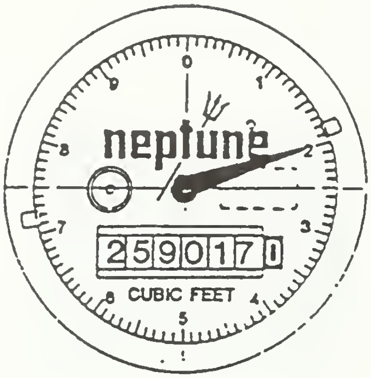


FIGURE 13. *Compound Meter*

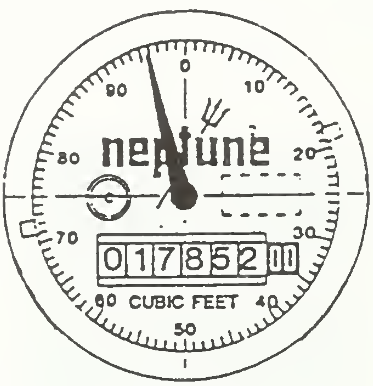
METER READING

Regardless of the type or accuracy of the meters, they are of little value in water management if they are not read frequently, and if the data then is not recorded and analyzed. As was discussed above, many water departments read meters infrequently. It is up to the facility to take action to track and review its water consumption.

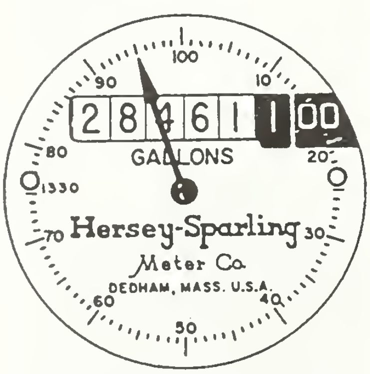
Meter dials come in a wide variety of configurations. Some common types are illustrated at left, along with the readings that they are indicating.



Ten Cubic Foot Meter
Reading is: 2,590,172 CU FT



Hundred Cubic Foot Meter
Reading is: 1,785,295 CU FT



Hundred Gallon Meter Reading
is: 28,461,100 Gallons

Appendix 1 of this document contains detailed information on meter reading.

Submetering

Major water uses within the facility should be "submetered." Submetering refers to meters installed by the customer to measure portions of the facility's total water consumption flowing to items of interest (for example, a cooling tower). As with the water department meters, it is necessary for submeters to be read frequently if they are to produce information that will be of value.

Leak Detection and Repair

Leaks can be categorized as either being visible or non-visible. Visible leaks are those which can be observed directly, such a faucet which cannot be closed completely and consequently discharges water continuously. It is unavoidable that, as equipment ages and incurs wear from its use in the facility, leaks will occur. The observations of employees should be the first key to leak detection. Plant personnel should be encouraged to identify and report leaks. It is important that prompt action be taken to repair leaks after they are reported, to demonstrate the management's commitment to leak control.

Non-visible leaks consist primarily of losses from underground piping. Although these are harder to detect, they constitute a far greater potential for water loss. Since the leaks are not visible, they usually are detected indirectly. One important method of detecting underground leaks is by noting unexplained increases in metered water consumption when they occur, or continued water consumption during facility down-time. If an underground leak is suspected, the next issue is to locate the leak at reasonable cost. Several methods are available for locating leaks in water pipelines. Most of these methods involve sonic detection; the loss of water from a pipe creates sound waves which can be detected by specially-designed equipment. This sort of leak detection work is usually performed by an outside service contractor. In some cases there may be signs on the ground surface that indicate a subsurface leak, such as unusually dense vegetation, or changes in soil conditions, such as subsidence. If a major underground leak is suspected, it should be located and repaired as quickly as possible; not only to conserve water, but also to prevent other damage that could be caused by the escaped water.

Steam systems should also be regularly maintained to prevent leaks and losses. Prevention of steam leaks will result in significant energy savings as well as water savings. Areas to examine include steam traps, relief valves, and condensate return pumps and piping.

APPENDICES

Appendix 1

Meter Reading

A wide variety of water meters are installed in facilities in the MWRA service area. Proper procedure is essential in obtaining correct readings. The following considerations should be kept in mind while reading meters:

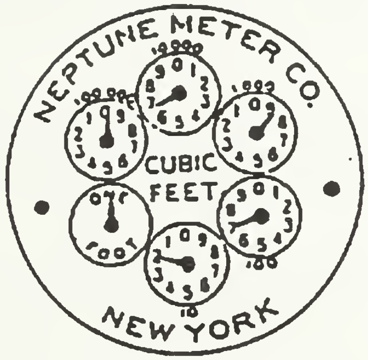
- Dial type: Straight reading or round reading.
- Measurement units: Cubic feet or gallons.
- Units per revolution.

Dial type. The two styles of meter dials are the "straight reading" and the "round reading" type. The straight reading meter has a numeric totalizer, similar to an odometer in an automobile. Figure A2-1 is an example of a straight reading meter. This is the more modern style of meter register and the reading is obtained by reading the numbers from the totalizer. This style dial also has a rotating pointer that is used to indicate the last one, two, or three digit places of the meter reading, depending upon the increments of the totalizer. This will be discussed in further detail below. The primary function of the pointer is to allow relatively small volumes of water to be measured through the meter for testing purposes.

Figure A1-1. *Straight reading meter dial.*
Reading is 1,785,295 cubic feet

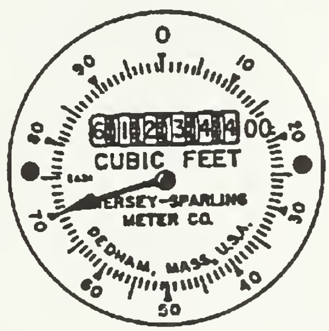
In many cases, water department meter readers are not concerned with the pointer position, as billing is based on larger units. For example, the most common case is for water to be billed in units of 100 cubic feet (Ccf or hcf). Typically, for billing purposes, the meter reader reads only the 100 cubic foot register and above and has no need for information from the smaller digit places (1's and 10's). However, plant staff might find this information useful and should in those cases read from the pointer as well. This is discussed later in more detail.

The other, older, style of meter dial is the "round reading" type, in which each digit of the meter reading is represented by a separated by a separate pointer dial. This style meter is similar to many electric meters, an illustration of a round reading meter is presented in Figure A1-2.



A1-2. *Round reading meter dial*
Reading is: 68,721 CU FT

Measurement units. Most water departments measure consumption and issue bills in terms of cubic feet or, more specifically, hundreds of cubic feet (Ccf). Consequently, most water meters are calibrated in cubic feet units, although many meters calibrated in gallon units also exist. The units of measure are printed on the meter dial, as shown in Figure A1-3.



A1-3. *Meter units are indicated on the dial*
Reading is 6,234,475 cubic feet

Obviously, it is crucial to be sure you know which units of measure are used by your meters. Reading a gallon meter as it is recording cubic feet will result in major errors in your calculations.

Many meters, especially in smaller sites, are provided to measure in gallon units. If you are working with meters with a mixture of units, you should make conversions between units as necessary to ensure you are using consistent figures.

Conversion factors are as follows:

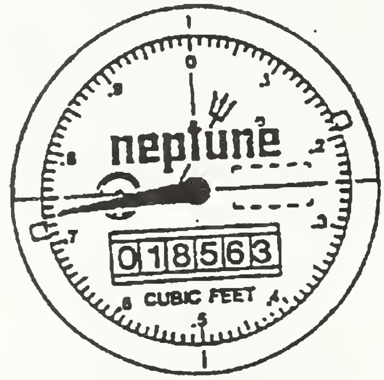
- 1 cubic foot (cu ft or cf) = 7.48 gallons (gal)

- 100 cubic feet (Ccf or hcf) = 748 gallons (gal)

Units per revolution. As noted previously, the last one, two, or three digit places for straight reading meters are indicated by a rotating pointer or needle, not the numeric register. On cubic foot metered, one revolution of the point could represent one, ten, or 100 cubic feet depending upon the particular meter. Failing to read this correctly means you will be off by a factor of 10 or more in your meter readings.

The numeric register indicates what units are used by the number of zeroes printed on the dial after the numeric register, as follows. In each case, one revolution of the pointer advances the last dial of the numeric register by one.

No zeroes: Meter registers numerically directly in cubic feet (or gallons, if it is a gallon meter); one revolution of the pointer is one cubic foot (or one gallon). An example is illustrated in Figure A1-4.



A1-4. *Cubic foot meter. Reading is 18,563.7 cuft*

One zero: Meter registers numerically in tens of cubic feet (or tens of gallons). One revolution of the pointer is ten cubic feet (or ten gallons); individual cubic feet (or gallons) can be read from the pointer's position on the scale around the meter's circumference. An example is illustrated in Figure A1-5.

A1-5. *Ten cubic foot meter. Reading is 6,234,476 cu ft.*

Two zeroes: Meter registers numerically in hundreds of cubic feet (or hundreds of gallons). One revolution of the pointer represents 100 cubic feet (or 100 gallons); smaller increments can be read using the position of the pointer on the circumferential scale. An example is illustrated in Figure A2-6

A1-6. *Hundred gallon meter. Reading is 28,416,730*

Three zeroes:Meter registers numerically in thousands of cubic feet (or thousands of gallons). One revolution of the pointer represents 1,000 cubic feet (or 1,000 gallons); smaller increments can be read using the position of the pointer on the circumferential scale. An example is illustrated in Figure A2-7.

A1-7. *Thousand gallon meter. Reading is 284,160,000*

Appendix 2

Water Management Plan Forms

WATER USE INVENTORY

Item	Number of Units	Location	Flow, gpm	Operating Time, minutes/day	Flow/day, gpd	Remarks

Water Consumption Summary

Period	Days in Period	Acct No. (Description)		Acct No. (Description)		Acct No. (Description)		Total	Average per Day
		Reading		Reading		Reading			

Water Efficiency Measures (WEMs)							
Water Efficiency Measure	Water/Sewerage Savings		Other Savings $/yr	Annual Costs $/yr	Net Annual Savings $/yr	Capital Cost $	Payback Period yr
	gal/yr	$/yr					

XYZ Corporation
Water Management Plan

Water Efficiency Measures	Person Responsible	Due Date	Initial Cost	Projected Annual Savings $	Gallons
1. Increase cooling tower consentration ratio from 4 to 10					
Call ABC Chemical Co. with change	Plant Engineer	March 15	--		
Install conductivity meter	Plumber, Electrian	April 30	$3000		
Install make-up and bleed-off meters	Plumber	April 30	1,500		
			4,500	$17,500	2,500,000
2. Install low-flow showerheads					
Order from EFG Plumbing	Plant Engineer, PurchasingManager	June 1	2,400		
Install showerheads	Plumber	July 15-30	1,800		
			42,00	$7,500	912,500
3. Replace water-cooled ice-maker with air-cooled model					
Order from HIJ Kitchen Supply		July 1	$4500		
Install		September 15-18	500		
Start-up		September 18	--		
			5000	$3,680	525,600
4. Employee Involvement Program					
Distribute plant manager memo on water efficiency	Plant Manager	March 1	--	--	--
Discuss at staff meeting	Plant Engineer, Shift Supervisor	March 15	--	--	--
Post flyers on employee bulletin board	Employee Relations Department	Monthly	--	--	--

APPENDIX 3

MWRA's Toxics Reduction and Control (TRAC) Program Sewer Use Discharge Permits: Incentives and Other Charges

These charges are designed to recover MWRA's costs for permitting, inspecting, and monitoring industrial users. There are two separate charges: a permitting charge and a monitoring charge.

The program provides incentives for flow and toxics use reduction as (a) industries who can reduce flows below 25,000 gpd and are not in Federally-regulated categories may be able to move from SIU to Non-SIU status resulting in lower permitting and monitoring charges; and (b) industries who can reduce their flows should be able to reduce their average loadings, thus lowering their monitoring point scores and ranking.

Permitting Charge

Category 1: Significant Industrial User (SIU); An industrial user subject to Categorical Pretreatment Standards under 40 CFR, 403.6 and 40 CRF, chapter 1, subchapter N; an industry which discharges an average of 25,000 gallons per day or more of process wastewater to the sewer system; or an industry which is designated as such by the MWRA on the basis that the industrial user has a reasonable potential for adversely affecting the operation of the collection system or treatment plant, or violating any pretreatment requirement. **$1,430**

Category 1: Non-SIU; A sewer user whose process results in a discharge containing one or more substances in a concentration or quantity requiring pretreatment to meet the requirements of 360 CMR 10.021 - 10.02. **$ 950**

Category 2: A sewer user whose process results in a discharge containing one or more substances in a concentration or quantity not requiring pretreatment to meet the requirements of 360 CMR 10.021 - 10.024. **$ 715**

Category 3: A sewer user whose process results in a discharge not containing a substance regulated by the MWRA or a photo developer with a silver recovery unit in place. **$ 575**

Other Categories: **$ 575**

Monitoring Charge

The monitoring charge is developed based upon an industry's "score" which is generated from average daily loadings of toxics to the system as ranked in comparison to other MWRA industrial sewer users.

SIUs: SIUs will be monitored a minimum of once per year.

	SIU with high monitoring point scores	$5,550
	SIU with medium monitoring point scores	$3,700
	SIU with low monitoring point scores	$1,850

Non-SIU: Non-SIUs:Facilities that are not SIUs, but have sampling requirements, will be monitored at a minimum of once every three years by TRAC staff.

Non-SIU $ 450

Point Scores:Highest points are associated with Copper, Lead, Mercury, Pesticides, Petroleum Hydrocarbons, Polychlorinated Biphenyls and Silver;

Second highest points are associated with Arsenic, Antimony, Cadmium, Chlorinated Napthalenes, Chromium (hexavalent and total), Cyanide, Fluoranthene, Hexachlorobutadiene, Nickel, Pentachlorophenol, Phenanthrene, Phenol, Phenolic Compounds, Selenium, Total Toxic Organics, Trichloroethylene, and Zinc.

Lowest points are associated with Fats, Oils, and Grease (FOG).

For additional information, call:
Kevin McManus, Director
Toxics Reduction and Control (TRAC)
(617) 241-2306

Appendix 4

Calculating Cooling Tower Water Savings

To determine the percentage of cooling tower water consumption that you can conserve by increasing the concentration ratio, use the following equation:

$$\text{PERCENT CONSERVED} = \frac{CR2 - CR1}{CR_1\,(CR_2 - 1)} \times 100 \text{ PERCENT}$$

where
CR1 = concentration ratio before increasing cycles,
and
CR2 = concentration ratio after increasing cycles.

As an example, increasing the concentration ratio from 4 to 10 results in a water savings of 16.7 percent as illustrated in the following example.

Example. The concentration ratio is increased from 4 to 10. What percentage of the cooling tower water consumption is conserved?

$CR_1 = 4;\ CR_2 = 10$

$$\text{PERCENT CONSERVED} = \frac{CR_2 - CR_1}{CR_1\,(CR_2 - 1)} \times 100 \text{ PERCENT}$$

$$= \frac{10 - 4}{4(10-1)} \times 100 \text{ PERCENT} = \frac{6}{36} \times 100 \text{ PERCENT} = \times 100 \text{ PERCENT} =$$

$$\frac{1}{6} \times 100 \text{ PERCENT} = 16.7 \text{ PERCENT}$$

Using the Cooling Tower Log Sheets

Log Sheet "A" is for data collection when makeup and bleed-off meters are used. The meters should be read daily, and not less frequently than weekly.

- Each meter reading for makeup water is entered in the second column from the left, and the bleed-off meter reading is entered in the fourth column.
- The metered makeup water consumption can be calculated by deducting the previous meter reading from the current reading and entering the difference in the third column.
- Bleed-off consumption, M, is calculated in the same fashion, with the difference between readings entered in the fifth column.
- Evaporation E, loss can be calculated by deducting bleed-off, B, from makeup, M.
- The concentration ratio is calculated as M divided by B, and entered in the seventh column.
- The eighth column is for remarks on unusual conditions or items of interest.

Log Sheet "B" is for data collection when the system is equipped with a conductivity meter or other means of measuring dissolved solids concentrations in makeup and bleed-off water.

- The second and third columns are for makeup water concentration, CM, and bleed-off water concentration, CB, respectively.
- Dividing CB by CM gives the concentration ratio which can be entered in the fourth column.
- By knowing the cooling load on the system, you can estimate the amount of water being lost to evaporation; this is equal to 3 gallons per minute per 100 tons of cooling. The next three columns of the table allow the evaporation to be calculated.
- Bleed-off and makeup water volumes can also be calculated based on the concentration ratio and volume of evaporation.
- The final column on the right is for remarks and notes.

COOLING TOWER LOG SHEET "A"

Cooling Tower ____________ Capacity ______ tons Location ____________________

Meter Units ____________ ____________________

Date	Makeup Meter Reading	Makeup Water Consumption, M	Bleed-off Meter Reading	Bleed-off Water Consumption, B	Evaporation E = M - B	Concentration Ration CR = M/B	Remarks

Log Sheet "A" to record metered makeup and bleed-off water volumes, and calculate conductivity value.

COOLING TOWER LOG SHEET "B"

Cooling Tower ____________ Capacity ______ tons Location ____________________

Parameter Measures ____________ Units ______ ____________________

Date	Makeup Concentration	Bleed-off Concentration, CB	Concentration Ratio, CR = CB/CM	Cooling Load, 100's of tons	Minutes per day, min/day	Evaporation, gpd E = 2.4 x (load) x (min/day)	Bleed-off, gpd B = E/(CR - 1)	Makeup, gpd M = B + E	Remarks

Log Sheet "B" is used to record metered makeup and bleed-off concentrations, and calculate concentration ratio.